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INDUSTRIAL COMPUTER PROGRAMMING ON THE BASIS OF LABORATORY STANDS

PROGRAMOWANIE KOMPUTERÓW PRZEMYSŁOWYCH W OPARCIU O STANOWISKA EDUKACYJNE

Abstract

One of the main weaknesses in the Laboratory of Distributed Control Systems at the AGH University of Science and Technology in Krakow was students' knowledge about connecting peripheral devices to industrial computers known also as PLCs. After participating in PLC laboratory course students were able to create advanced programs, control complicated mechatronic systems but they could not assemble even simple electrical circuits. It results from the fact that they worked on ready-made laboratory stands where all the electrical connections had already been set.

The paper presents the building of eight laboratory stands for learning how to connect PLC inputs and outputs as the first step before proper programming.

Keywords: PLC programming, test stands

Streszczenie

Jednym z największych braków w Laboratorium Rozproszonych Systemów Sterowania w Katedrze Automatyzacji Procesów w Akademii Górniczo-Hutniczej w Krakowie był do tej pory brak wiedzy zdobywanej przez studentów na temat podłączania elementów zewnętrznych do sterownika przemysłowego PLC. Studenti po zakończeniu zajęć laboratoryjnych potrafili tworzyć zaawansowane oprogramowanie, sterować skomplikowanymi układami mechatronicznymi, natomiast nie potrafili wykonać żadnych, nawet bardzo prostych połączeń elektrycznych. Wynikało to z faktu, że pracowali na stanowiskach, gdzie wszystkie połączenia elektryczne zostały wcześniej wykonane. W artykule opisano wykonanie ośmiu stanowisk dydaktycznych do nauki prawidłowego łączenia wejść i wyjść sterownika przemysłowego jako pierwszy krok przed nauką właściwego programowania. Postanowiono, że będą one służyć w przyszłości studentom do nauki zasad prawidłowego łączenia ze sobą poszczególnych elementów w nieskomplikowane układy automatyki będące bazą do ich późniejszego rozwoju.

Słowa kluczowe: programowanie sterowników przemysłowych PLC, stanowiska laboratoryjne

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1. Introduction

The classes conducted in the Laboratory of Distributed Control Systems (LDCS) at the University of Science and Technology in Krakow are considered by our students as one of the most interesting and useful ones in their future engineer career in industry. It is a result of many years of laboratory development and gathering over thirty industrial computers operating together with different test stands. In this laboratory four subjects are taught from the first contact with PLCs to learning advanced programming. The laboratory holds a good reputation so a lot of students who are not planned to work there ask the teachers to be allowed to participate in classes outside the scope of the syllabus.

So far one of the main weaknesses was students' knowledge about connecting peripheral devices to industrial computers. After participating in PLC courses students were able to create very advanced programs, control complicated mechatronic systems e.g. control the position of photovoltaic cells, but they could not assemble even a simple electrical circuit. It results from the fact that they worked on ready-made laboratory stands, where all the electrical connections had already been set.

The topic of connecting peripheral devices was, of course, discussed during classes but as it is widely known theoretical knowledge in comparison with practical one is poorly comprehended. That is why it was decided that the described gap should be eliminated as it is described in the article.

The article presents the building of eight laboratory stands for learning how to connect PLC inputs and outputs as the first step before proper programming. It allows students not only to learn about PLC connections but also learn in practice the principles of operating different automatics devices e.g. proximity switches.

2. The conception of the laboratory stands

The preliminary analysis inclined us to integrate all peripheral devices together with an industrial computer in one closed housing. The proposed solution was chosen with respect to the students' safety because all of the 230 V power supply voltage wiring was hidden under the cover. In this way students have a possibility to touch only the safe 24 V voltage. Additionally, the housings are easy to manage during classes, as they may be connected to any PC computer or even can be used in another laboratory. As it was mentioned the main idea of the laboratory stands was educating students so the cover of the housing was prepared as a kind of interface between a user and the laboratory stand. That is why the cover was made of transparent Plexiglas with printed electrical symbols and descriptions. Panel mounting banana sockets and wires with banana plugs allow to make the connections.

Figure 1 presents the housing before electrical elements assembly. The chosen material for housing was black Plexiglas UV-proof and it was resistant to damage which may occur when used by students. Both the cover and the housing were made of 5 mm material which created a rigid construction. The housing dimensions were set bearing in mind the optimal placement of electrical connections, i.g. 24V power supply sockets next to the 24V switch. As a result, the housing of 330mm in length, 180mm in width and 60mm in height was created. The holes and cut-outs for electrical devices were also prepared in the cover.

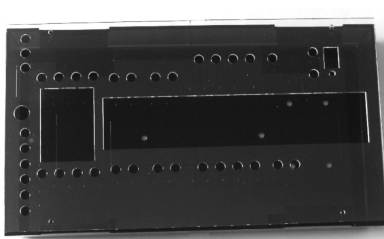


Fig. 1. The housing before electrical elements assembly

Rys. 1. Skrzynka przed montażem elementów elektrycznych

3. Devices assembly

The next step after preparing the housing fixing devices in it in a proper way. The following devices: a circuit breaker, a power supplier, a simple industrial computer (programmable relay NEED family), push buttons and a contactor were fixed to the internal

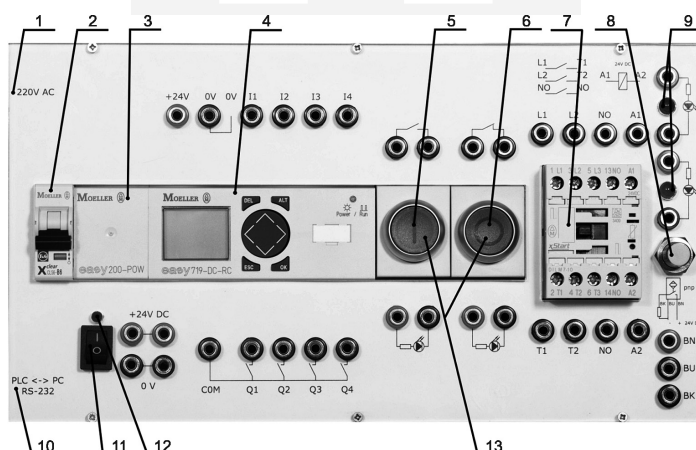


Fig. 2. The front panel of the laboratory stand: 1 – 230V AC socket, 2 – circuit breaker CLS6–B6, 3 – power supplier 24 V DC, 0.2 A, 1 phase, 4 – industrial computer (programmable relay) EASY 719-DC-RC, 5 – green push button (NO contact), 6 – red push button (NC contact), 7 – 3-phase contactor DILM 7–10, 8 – proximity sensor PR12 – 2DP, 9 – diodes LED, 10 – RS232 communication port for programming EASY device, 11 – 24 V switch, 12 – 24 V power supply indicator, 13 – diodes LED built in push buttons

Rys. 2. Panel przedni stanowiska: 1 – 230 V AC gniazdo, 2 – wyłącznik nadprądowy CLS6–B6, 3 – zasilacz 24 V DC, 0.2 A, 1 – faza, 4 – przekaźnik sterowalny EASY 719-DC-RC, 5 – przycisk zielony (NO styk), 6 – przycisk czerwony (NC styk), 7 – 3-fazowy stycznik DILM 7–10, 8 – czujnik zbliżeniowy PR12 – 2DP, 9 – diody LED, 10 – RS232 port komunikacyjny, 11 – 24 V wyłącznik, 12 – 24 V dioda zasilania, 13 – diody LED wbudowane w przyciski

DIN mounting rail. It is a metal rail of a standard type widely used for mounting industrial automatic equipment.

Other elements were fixed to the prepared cut-outs in the cover: a proximity switch with using a screw cap, 24V switch with a special construction of the switch itself (interference with the cover), a panel mounting banana socket with screw joints, and finally light-emitting LED diodes in the cover holes. The front panel of the laboratory stand is presented in Figure 2.

The front panel is arranged in a way that all connections and all descriptions are easy to comprehend and to use properly. The whole idea of the stand is to teach how to connect different devices with an industrial computer and with each other as well.

To fulfil the task the panel mounting banana sockets were connected inside the housing with all electrical connections of the available devices e.g. the industrial computer inputs (I1–I4) or green NO contact push buttons. The sockets visible for users can be connected with each other by using wires with banana plugs (Fig. 3).



Fig. 3. The panel mounting a banana socket (left) and the wire with banana plugs (right)

Rys. 3. Gniazdo banankowe (z lewej) przewód z końcówkami banankowymi (po prawej)

4. Description of the used devices

The main part of the stand is the industrial computer. It is a digital computer which unlike general-purpose computers is designed for cooperating with the environment (industrial process) by multiple inputs and output. Also known as a Programmable Logic Controller, it is very widely used in all kinds of modern industry, wherever there is a need to control a machine or a set of machines – which is especially true with assembly lines and mass production which could not exist without PLCs [3].

In the case of the laboratory stand the industrial computer EASY 719-DC-RC made by Moeller company was used. It is a very simple type of computer and sometimes in catalogues it is classified as a programmable relay. However, nowadays differences between a programmable relay, a programmable logic controller and a more sophisticated industrial computer are vanishing and generally they are regarded as one family, very similar in operation but with different capacity.

The used EASY device presented in figure 4 consists of LCD display and keyboard so a user can program it without using a PC computer. 8 inputs (6 digital inputs and 2 analog-digital inputs) and 4 relay outputs (4×1 NO) are available in very small package [4].

Finally, figure 5 shows a graphical presentation of a sample task given to students where they were required to create electrical connections of a latch circuit with STOP priority – a basic connection of push buttons used widely in industry [1, 2].

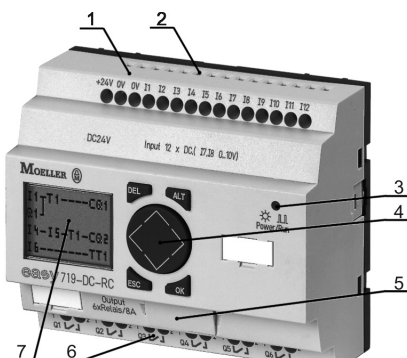


Fig. 4. The industrial computer EASY 719-DC-RC: 1 – power supply connections, 2 – inputs, 3 – power/run indicator, 4 – keyboard, 5 – communication port, 6 – outputs, 7 – LCD display

Rys. 4. Komputer przemysłowy (przełącznik programowalny) EASY 719-DC-RC: 1 – podłączenie zasilania, 2 – wejścia, 3 – diody zasilania i trybu pracy, 4 – klawiatura, 5 – port komunikacyjny, 6 – wyjścia, 7 – LCD wyświetlacz

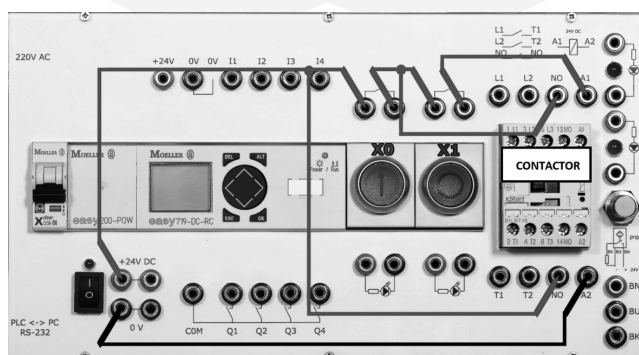


Fig. 5. The electrical connections of a latch circuit with STOP priority

Rys. 5. Elektryczne podłączenie styku z podtrzymaniem z priorytetem STOP

The tasks ranging from very simple (connect one device to the PLC) to the tasks requiring usage of twenty wires are included in the prepared instructions.

5. Conclusions

In the article the building of the laboratory stands for learning how to connect PLC inputs and outputs was presented. During the construction process two preliminary housings were designed but only the third (presented) one met the authors expectations. The maintenance of the stands was high on the priority list. That is why the cover was fixed to the housing in such a way that it is very easy to access the internal connections – it is possible to fix the broken

connection even during classes and it requires only a few minutes. The industrial safety was also very important, that is why a dangerous 230 V are beyond a user's reach.

The instructions for students were also prepared where the additional technical data about test devices together with a series of individual tasks were attached.

As the result of building described in the article test stands a student after two laboratory classes is fully prepared to connect electrical devices in their future engineering career.

References

- [1] Dominik I., *PLC's programming with examples*, DELTA J., A. JAGŁA, cop. 2011, s. 127, ISBN 978-83-62139-34-7, Kraków 2011.
- [2] Flaga S., *Programowanie sterowników PLC w języku drabinkowym*, Wydaw. ResNet S.C., ISBN 83-921949-0-X, Skawina 2005.
- [3] Kwaśniewski J., *Sterowniki PLC w praktyce inżynierskiej*, Legionowo, Wydawnictwo BTC, s. 344, cop. 2008.
- [4] Moeller company, *Easy i MFD – Titan w praktyce. Przykłady aplikacji dla przekaźnika programowalnego easy*, Manual 2010.

